Unique X-Ray Probes for Aluminum, Silicon, and Magnesium Materials

Important new information from the 1- to 2-keV energy region

The 1- to 2-keV energy region has been virtually closed to soft x-ray spectroscopy and inaccessible to both grating and crystal monochromators. In a recent breakthrough, however, we have developed a new YB_{66} monochromator that allows us to study this important energy region. With our unique facility, we can now characterize industrial materials containing aluminum (1559 eV), silicon (1839 eV), and magnesium (1303 eV).

Applicable materials

- Zeolites, aluminosilicate catalysts, and glasses
- Clay minerals
- Hi-tech aluminum and magnesium alloys
- Silicon-based ceramics and electronic materials

New monochromator technology

At Lawrence Livermore, we developed our YB_{66} monochromator to disperse high-energy, intense synchrotron radiation in this soft x-ray region. A complex, binary semiconductor, yttrium boride (YB_{66}), with its cubic crystal structure and lattice constant of 23.44 Å, is an ideal candidate for the task. Our pioneering work was the recipient of an *R&D Magazine* award as one of the 100 best new technologies in 1991 and has since been successfully installed as a double-crystal monochromator on the JUMBO beamline at the Stanford Synchrotron Radiation Laboratory.

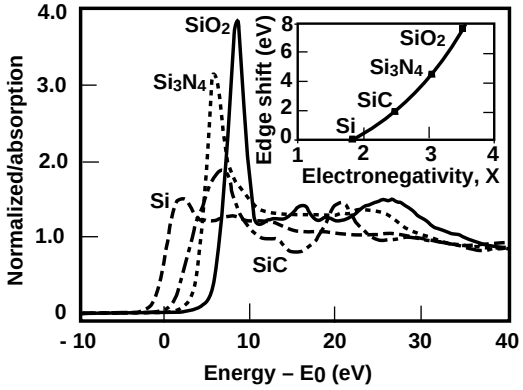
APPLICATIONS

- *Diagnostics for catalytic processes*
- *Process diagnostics for the petroleum industry*
- *Diagnostics for the electronics industry*

An example

The figure shows the high-resolution x-ray absorption near-edge spectroscopy (XANES) spectra of silicon, SiC, Si_3N_4, and SiO_2. Two significant trends are apparent:

- A progressive positive edge energy shift from silicon to SiC to Si_3N_4 to SiO_2 and



Normalized silicon K-edge XANES spectra of crystalline silicon, α-SiC, α-Si_3N_4, and SiO_2 (α-quartz)—all of which are tetrahedrally coordinated.

- An accompanying systematic increase in the intensity of the dominant bound-state transition.

In each crystal structure, the central silicon atom is tetrahedrally coordinated, and the next-nearest neighbor is another silicon. These trends can be explained by the bonding ligand electronegativities—which increase in the order C < N < O—as shown in the figure inset. These edge energy shifts are useful in chemical microtomographic imaging of electronic devices containing silicon-based thin films.

Availability: This unique facility is operational now and is available to industrial partners in petroleum, electronics, and other industries interested in characterizing and monitoring manufacturing processes of aluminum-, silicon-, and magnesium-based materials.

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